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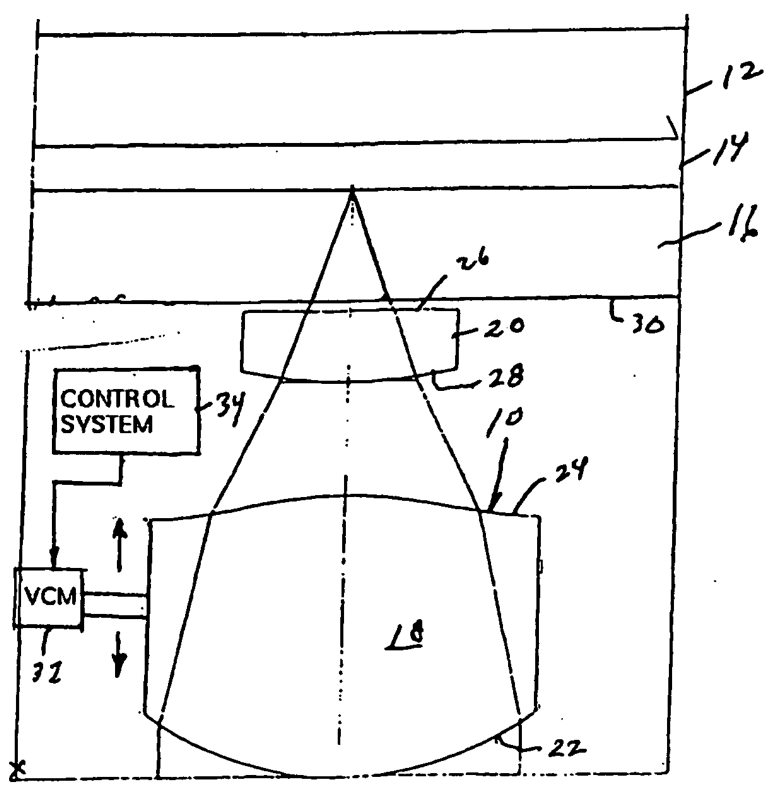
(54) Title: SPHERICAL ABERRATION CORRECTION USING FLYING LENS AND METHOD

(57) Abstract

An optical access device for a moving optical data storage media having a flying lens (20) near an outer surface of the media (12), and an objective lens (18) spaced from the flying lens, with the flying lens and objective lens co-operating to substantially offset a variable range of negative spherical aberration occurring in the media by forming a positive spherical aberration which substantially cancels the negative spherical aberration.



SPECIFICATION

TITLE

SPHERICAL ABERRATION CORRECTION USING FLYING LENS AND METHOD

This application is related to Application Serial No. 09/016,213, filed January 30, 1998, Application Serial No. 09/016,382, filed January 30, 1998, and Application Serial No. 09/071,478, filed May 1, 1998.

1. Field Of The Invention

The present invention relates to optical focusing, and more particularly to the correction of spherical aberration for data storage media.

2. Background of the Invention

The use of optical data storage disks having a single data storage layer is known. Such disks include, for example, compact disks (CDs) and CD-ROMs, magneto-optical disks (M/O), and some digital video disks (DVD). More recently it has been proposed that optical data storage disks be increased in storage capacity by having multiple data storage layers, and limited use of two layers has been introduced on the market. Such multilayer disks would have a plurality of inner data storage layers and an outer protective layer for protecting the data storage layers from scratches and dust.

In such storage disk systems, a focused beam of light is reflected from a modulation at a point in a data storage layer, such as a pit, magneto optical bit, phase change bit, or dye polymer bit, and the way in which the beam is reflected determines the value of the data stored at that point.

It is also known that both the data storage layer and protective layer cause a spherical aberration to the light accessing both layers, which is different for different data layers, and

Simultaneous depth selection and spherical aberration correction is accomplished by maintaining a corrector lens at a fixed distance away from an outer surface of the media and an objective lens spaced at a variable distance from the corrector lens. The corrector lens and objective lens spaced at a variable distance from the corrector lens. The corrector lens and objective lens co-operate to substantially offset a variable negative spherical aberration occurring in the media by forming a positive spherical aberration which substantially cancels the negative spherical aberration.

A nominal separation distance, the corrector lens and the objective lens correct for a fixed amount of spherical aberration. Variations about this nominal distance correct for dynamic spherical aberration. The objective lens moves relative to the corrector lens to access different depths of the storage region. The lens system also accommodates different thicknesses of the protective layer.

In certain embodiments, the corrector lens takes the form of the flying lens situated near the surface of the medium. The flying lens is kept at a relatively fixed distance from the surface using an air bearing system, even in the event of a tilt of the media, without the use of complicated servo control algorithms and electronics. Generally, the distance between the flying lens and the outer surface of the media is dependent upon the speed of the media relative to the correcting lens. In preferred form, only one actuator corresponding to one movable lens is required in the operation of the device.

In certain embodiments, the device has an air bearing system comprising a slider having the flying corrector lens recessed from an inner or outer surface of the slider. Alternatively, the lens could protrude out of the outer surface. The slider preferably has a beveled leading end on each side for air flow and life. The system can also have a device for biasing or preloading the slider towards the outer surface of the media.

In a presently preferred form, by way of example and not necessarily by way of limitation, the storage media comprises a storage region with a plurality of data layers, and an outer protective layer to cover said storage region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of an optical access device of the present invention.

FIG. 2 is a plan view of a flying lens for the device of the present invention.

The device 12 has an outer objective lens 18 and an inner flying spherical aberration corrector lens 20 positioned near the disk 12 intermediate the objective lens 18 and the disk 12. The disk 12 is typically in the far field of the lens. The objective lens 18 preferably has an aspheric outer surface 22 and an opposed inner aspheric surface 24. The corrector lens 20 has a generally planar inner surface 26 facing the disk 12, and a convex outer surface 28 facing away from the disk 12, which is preferably spherical, or it may be aspherical, e.g., for special correction of disk tilt. The objective lens has an optimal thickness, but it has been found that the objective lens 18 performs satisfactorily if the thickness is in a range of about 30μm greater than or less than the optimal thickness.

The surfaces of the objective lens 18 and the corrector lens 20 are selected to form a positive spherical aberration, which offsets the negative spherical aberration caused by the disk 12, as well as focusing on a given data layer in the disk 12. Thus, the two lenses simultaneously result in the correction of spherical aberration as they focus a beam on the selected data layer. The corrector lens 20 corrects for a dynamic spherical aberration in the storage region 14 of the disk 12, while the objective lens 18 corrects for a fixed spherical aberration in the disk 12. In accordance with a preferred embodiment of the present invention, variable thicknesses of the protective layer 16 may be used in the disk 12, such as in the range of about 0.6 mm to about 1.2 mm, while the depth of accessing information in the storage region 14 may be in the range of about 0.0 mm to about 1.0 mm from an outer surface of the storage region 14. In a preferred form, the corrector lens 20 is positioned slightly away from an outer surface 30 of the disk 12 in the range of about 50 μm to about 200 μm. Situating the corrector lens 20 close to the disk 12 increases the depth over which spherical aberration tolerances can be met, and increases disk tilt tolerances.

As shown, the objective lens 18 has an associated actuator 32, such as a voice coil actuator, or voice coil motor (VCM), known to the art, which moves the objective lens 18 relative to the corrector lens 20. In this manner, the lens assembly may access different depths or data layers of the storage region 14 by simply actuating the actuator 32 which moves the objective lens, as controlled by a suitable control system 34, such as a digital signal processor (DSP). The objective lens 18 may also be moved by the actuator 32 in order to simultaneously modify the spherical aberration and focusing. As will be seen below, the corrector lens 20 is positioned at a nearly constant distance from the outer surface 30 of the disk 12 so that the focus position and spherical aberration can be linked, such that a separate control for spherical aberration and focusing is not required.

In a preferred form, as shown in FIGs 1-4, the device 10 has a slider 36 having the flying corrector lens 20 recessed from an inner surface 38 and outer surface of the slider 36 in order to protect the inner and outer surfaces of the corrector lens 20, and the corrector lens 20

Different layers of the optical data storage region may be accessed in the disk 12 by merely moving the objective lens 18 relative to the flying lens 20. Thus, the device 10 of the present invention is of simplified construction, and provides improved results.

A device 10 and 10' for generating reflective microholograms is illustrated in FIG. 6, in which like reference numerals designate like parts. In this embodiment, the device 10 has a structure as previously described in connection with FIGs. 1-5 adjacent the outer surface 30 of the disk 12. In addition, the device 10' has a flying corrector lens 20' including a slider flying at a fixed position near an opposite outer surface 30' of the disk 12. The device 10' also has an objective lens 18' spaced from the corrector lens 20', and an auxiliary lens 50' to focus the light beam on the outer surface of a mirror 58'.

In use, the device 10 and 10' of FIG. 6 has a laser source 48 forming a light beam which passes to the collimator lens 50 and to the beam splitter 52. After that, the beam passes through the objective lens 18 and corrector lens 20. The beam then passes through the disk 12 to the second flying corrector lens 20' near the opposed surface 30' on the opposite side of the disk 12. After that, the beam passes through the second objective lens 18' to the auxiliary lens 50' which focuses the beam on the outer surface of the mirror 58' . The beam is reflected by the mirror 58', and again passes through the second collimator auxiliary lens 50', the second objective lens 18' and second corrector lens 20' where the beam is focused in the storage region 14 of the disk 12 in the vicinity of the focused beam from the device 10 in the storage region 14. At this point or area, the two opposed beams form an interference pattern having dark and light areas, and, in the present case, the interference pattern forms reflection microholograms in the storage region 14 which serves later as a representation of stored data. The device 10 previously described in connection with FIGs 1-5 is used in order to read the information which has been generated in the storage region 14 of the disk 12 by the device of FIG. 6.

As shown in FIG. 7, a method of the present invention of accessing a moving optical media comprises the steps of directing a light beam into the media 60, and offsetting a variable negative spherical aberration occurring in the media by forming a positive spherical aberration of reflected light from the media which substantially cancels the negative spherical aberration 62.

As shown in Fig. 8, another method of the present invention of accessing a moving optical storage media comprises the steps of flying a corrector lens at a nearly constant distance away from an outer surface of the media to pass light and correct for spherical aberration 64, and passing light received by the corrector lens through an objective lens to further correct for spherical aberration 66.

What is Claimed is:

1. An optical access device for a moving optical storage media, comprising:

a flying lens near an outer surface of said media; and

an objective lens spaced from the flying lens, said flying lens and objective lens co-operating to substantially offset a variable range of negative spherical aberration occurring in said media by forming a positive spherical aberration which substantially cancels said negative spherical aberration.

2. The device of claim 1 wherein said media includes a storage region covered by a protective layer of preselected variable thickness.

3. The device of claim 2 wherein the thickness of said protective layer is in the range of about 0.6 mm to about 1.2 mm.

4. The device of claim 2 wherein the depth of accessing information in the storage region of said media is in the range of about 0.0 mm to about 1.0 mm from an outer surface of the data storage region.

5. The device of claim 1 further comprising a moving device for moving the objective lens relative to said flying lens.

6. The device of claim 1 wherein said flying lens has an inner generally planar surface facing said outer surface of the media.

7. The device of claim 6 wherein said flying lens has a convex outer surface facing away from the outer surface of said media.

8. The device of claim 7 wherein said outer surface of the flying lens is substantially spherical.

9. The device of claim 7 wherein said outer surface of the flying lens is aspherical.

10. The device of claim 1 wherein said objective lens is aspherical.

11 The device of claim 1 wherein said flying lens is positioned at a nearly constant height spaced away from said outer surface of said media.

25. An optical access device for an optical storage media which is removable or fixed in the device, comprising:

a corrector lens;

a device for maintaining the corrector lens at substantially the same distance from an outer surface of the media; and

an objective lens spaced from the corrector lens, said corrector lens and objective lens co-operating to substantially offset a variable range of negative spherical aberration occurring in said media by forming a positive spherical aberration which substantially cancels said negative spherical aberration.

26. An optical access device for an optical storage media, comprising:

a flying lens near an outer surface of said media;

a device for preloading the flying lens towards the outer surface of said media; and

an objective lens spaced from the flying lens, said flying lens and objective lens co-operating to substantially offset a variable range of negative spherical aberration occurring in said media by forming a positive spherical aberration which substantially cancels said negative spherical aberration.

27. The device of claim 26 further comprising a slider with an air bearing system for retaining the flying lens.

28. The device of claim 27 wherein the slider with the air bearing system is spaced at approximately a constant distance from the outer surface of said media when the media is in motion relative to the lens.

29. The device of claim 27 wherein an inner surface of said slider contacts the outer surface of the media when the media is at rest or in a condition of slow motion.

30. The device of claim 29 wherein the flying lens is spaced from an inner surface of said slider.

31. An optical access device, comprising:

44. An optical access device for a moving optical storage media, comprising:

a flying lens near an outer surface of said media; and

an objective lens spaced from the flying lens, said flying lens and objective lens co-operating to substantially offset a variable range of negative spherical aberration occurring in said media by forming a positive spherical aberration which substantially cancels said negative spherical aberration, and to substantially focus on a given data layer of the media.

45. The lens of claim 44 wherein an inner surface of said flying lens is approximately planar, and in which an outer surface of said flying lens is convex.

46. The lens of claim 45 wherein the outer surface of said flying lens is spherical.

47. The lens of claim 45 wherein the outer surface of said flying lens is aspherical.

48. An optical access device for a moving removable or fixed optical storage media, comprising:

a flying lens maintained at a substantially constant distance from an outer surface of said media;

an objective lens spaced from the flying lens, said flying lens and objective lens co-operating to substantially offset a variable negative spherical aberration occurring in said media by forming a positive spherical aberration which substantially cancels said negative spherical aberration; and

a moving device for moving the objective lens relative to said flying lens.

49. An optical access device for a moving removable or fixed optical storage media, comprising:

a flying lens maintained at a nearly constant distance away from an outer surface of said media;

an air bearing system with a slider having the flying lens recessed from an inner surface of the slider, said flying lens having an inner generally planar surface, and an outer convex surface; and

57. The device of claim 55 wherein said outer surface of the flying lens is aspherical

58. A method of accessing a moving optical storage media, comprising the steps of:

directing a beam of light into said media; and

offsetting a variable range of negative spherical aberration occurring in said media by forming a positive spherical aberration of reflected light from said media which substantially cancels said negative spherical aberration.

59. A method of accessing a moving optical storage media, comprising the steps of:

flying a corrector lens at a nearly constant distance away from an outer surface of said media to pass light and correct for spherical aberration; and

passing light received from said corrector lens through an objective lens to further correct for spherical aberration.

60. The method of claim 59 including the step of moving said objective lens relative to said corrector lens to access different depths in a storage region of said media.

61. A method of accessing a moving optical storage media, comprising the steps of:

flying a corrector lens at a nearly constant distance away from an outer surface of said media to pass light and correct for spherical aberration in the media; and

passing light received from said corrector lens through an objective lens to correct for spherical aberration and focus on a given data layer in the media.

62. The method of claim 61 including the step of moving said objective lens relative to said corrector lens to access different depths in a storage region of said media.

63. A method of accessing a removable or fixed optical storage media, comprising the step of:

flying a corrector lens at a nearly constant distance from an outer surface of said media, said distance being dependent upon the speed of said media.

74. The device of claim 70 wherein said media comprises a rotating disc, and in which said beveled end is disposed in an opposite direction to the direction of the rotation of said disk.

75. An optical access device for a moving optical storage media comprising, a lens assembly which simultaneously corrects for spherical aberration due to the media and focus on a given data layer in the media.

76. An optical access device for a moving optical storage media having a data storage region of multiple depths and a protective layer over said storage region comprising, a flying lens, and an objective lens, wherein the objective to flying lens spacing corrects for dynamic spherical aberration, and the objective to flying lens at nominal spacing corrects for fixed spherical aberration.

77. The device of claim 76 further comprising a device for moving the objective lens relative to said flying lens.

78. An optical access device for a moving storage media, comprising:

a flying lens near an outer surface of said media; and

an objective lens spaced from the flying lens, said flying lens and objective lens co-operating to cancel spherical aberration, said objective lens having an optimal thickness, and an actual thickness which may be greater than or less than the optimal thickness.

79. The device of claim 78 wherein the range of thickness is about 30 μm greater than or less than said optimal thickness.

80. An optical data generator for a moving optical storage media having opposed outer surfaces, comprises:

a first flying lens near a first of said opposed outer surfaces of the media;

a first objective lens spaced from the first flying lens;

a second flying lens near a second opposed outer surface of the media; and

a second objective lens spaced from the second flying lens.

81. The generator of claim 80 wherein the media comprises a disk.

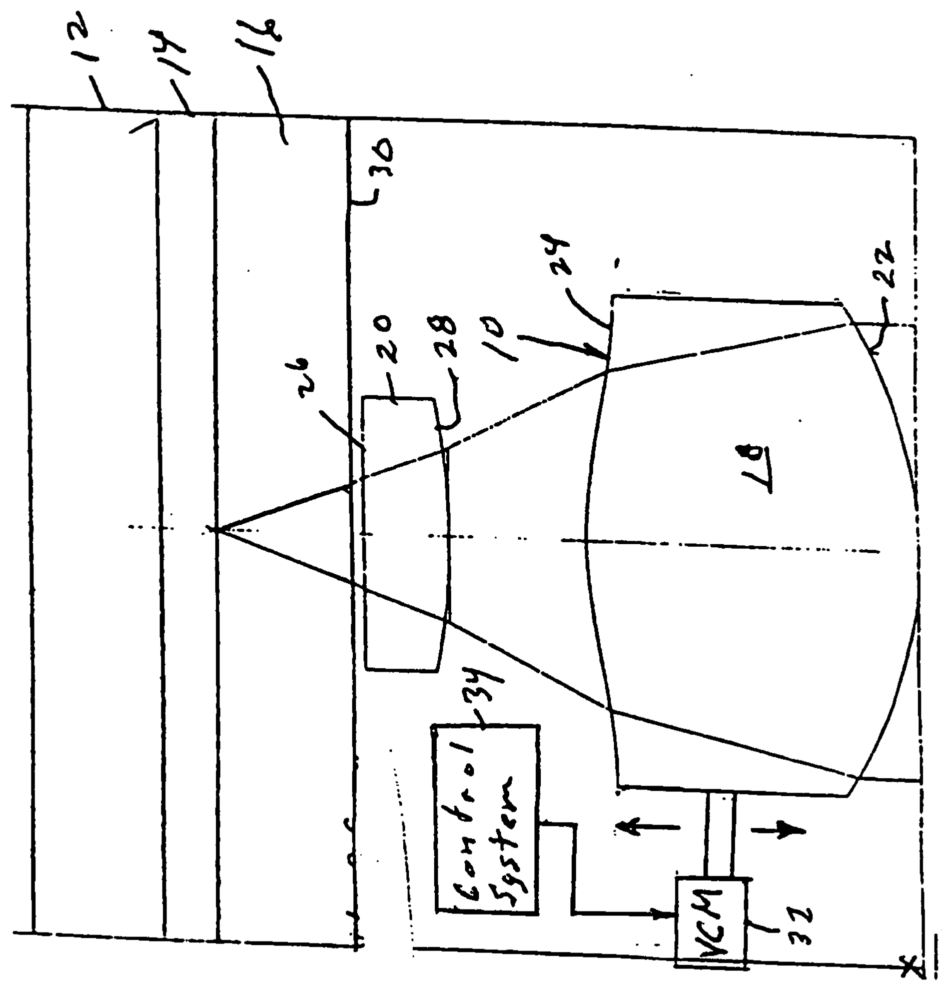


FIG. 1

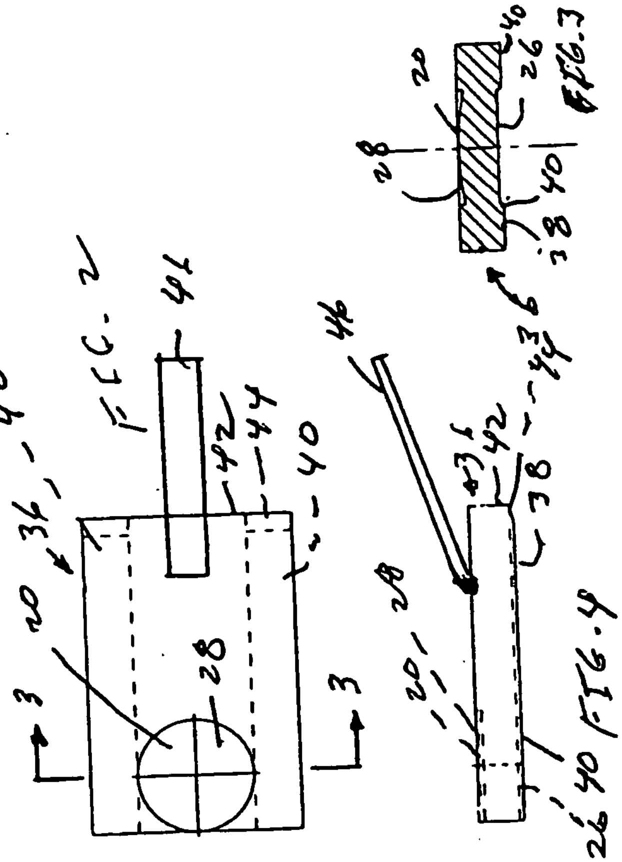


FIG. 2

FIG. 3

FIG. 4

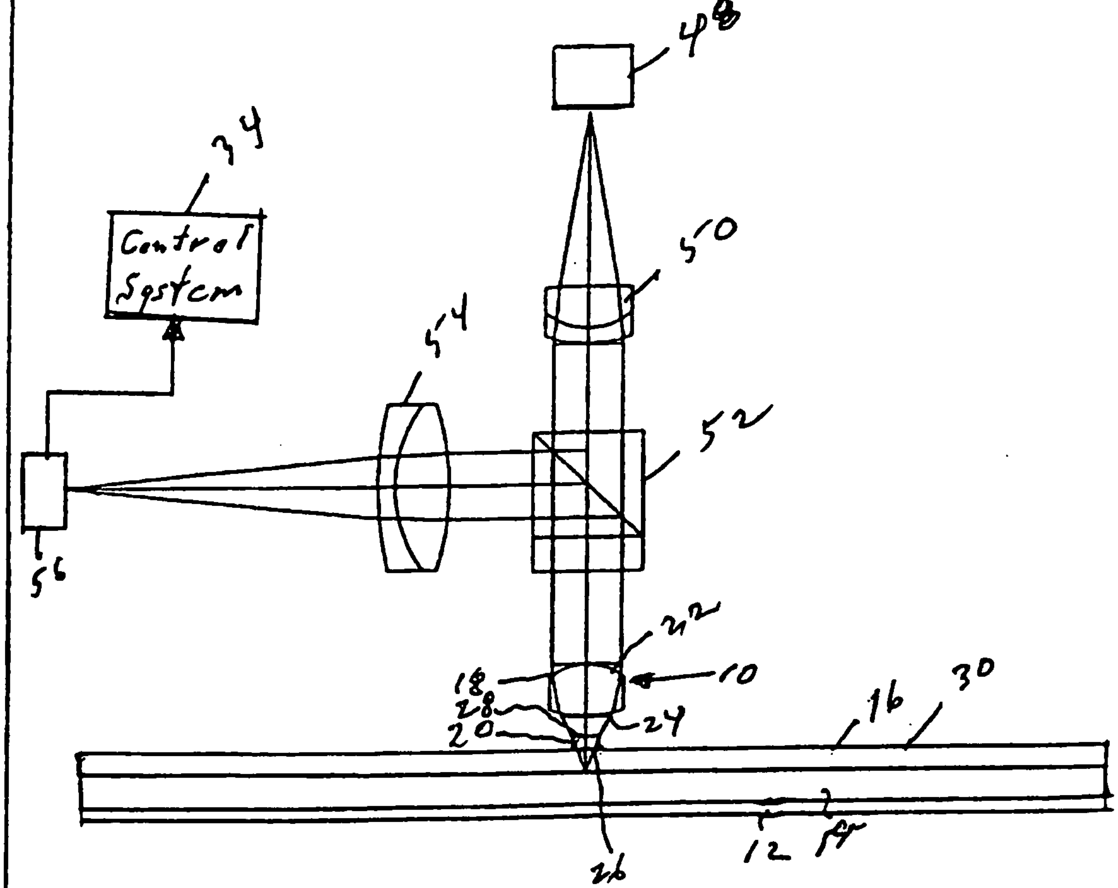


FIG. 5

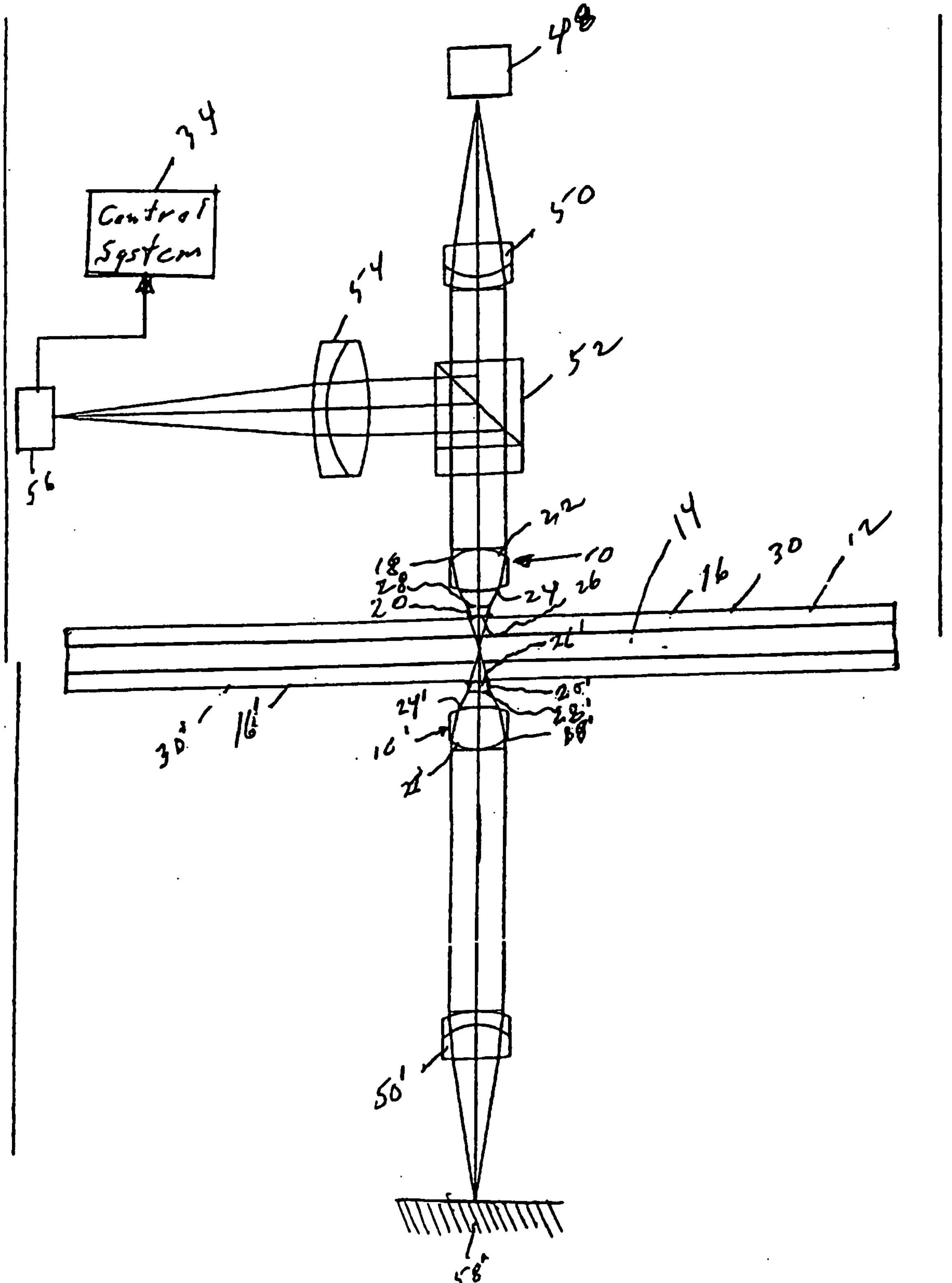
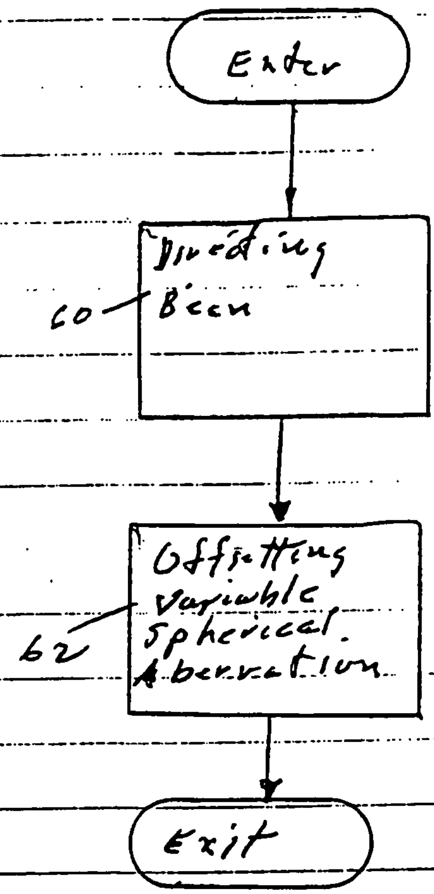

48
34
Control System
50
54
52
56
22
10
18
28
20
24
26
14
16
30
12
26'
20'
24'
28'
18'
10'
22'
30'
16'
50'
58'

FIG. 6

FIG. 7


Enter
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60
Offsetting variable Spherical Aberration
62
Exit

FIG. 8

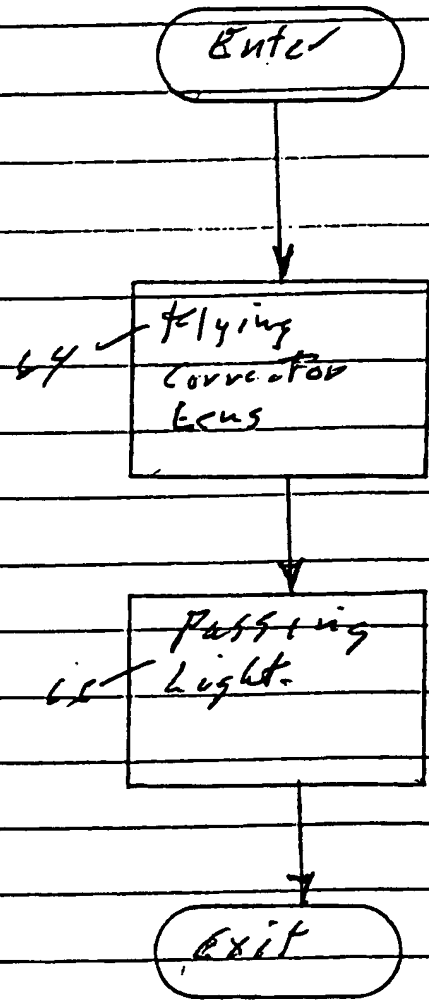


FIG. 9

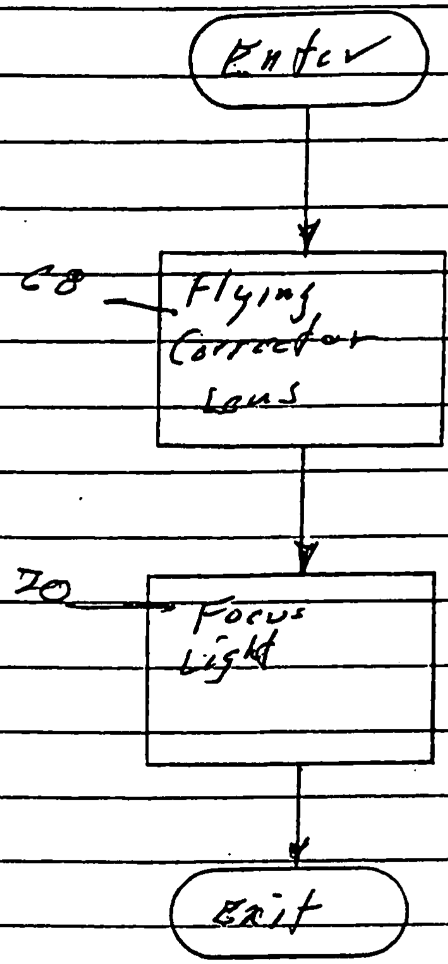
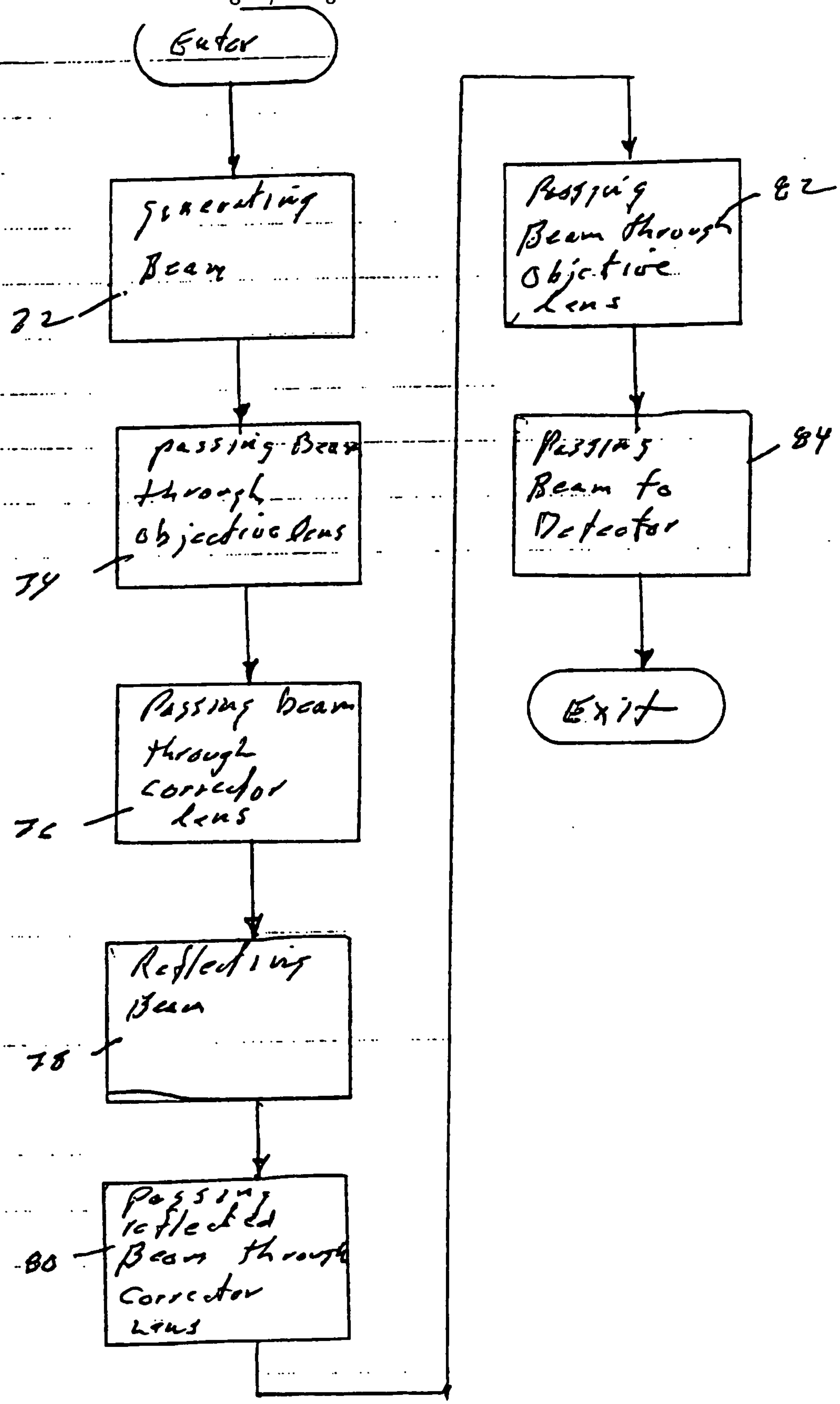


FIG. 10


Enter
Generating Beam
72
passing Beam through objective lens
74
Passing beam through corrector lens
76
Reflecting Beam
78
Passing reflected Beam through Corrector Lens
80
Passing Beam through objective Lens
82
Passing Beam to Detector
84
Exit

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/14973

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B7/135 G11B7/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 727 777 A (SONY CORPORATION) 21 August 1996 (1996-08-21) column 4, line 4 - line 49; figure 2 column 7, line 13 - line 32; figure 7	1,6-8, 10-31, 35-37, 39-41, 43, 49-51, 54,58, 59,61, 63-74,84

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 October 1999	22/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gerard, E

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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